Silicon Membrane Thickness Monitoring System based on Optical Sensing system

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Introduction

Silicon wafer etching is frequently used in micromachining and microelectronic fabrication processes. How to precisely control the thickness of etched silicon membrane is very challenging. Controlling the etching depth by controlling the etching time can result in large errors due to fluctuation of etching rate. A more accurate in-situ silicon membrane thickness monitoring system during silicon wafer etching is very necessary.

In this poster, we proposed a silicon membrane thickness in-situ monitoring system based on optical sensing. A halogen lamp generates light to be passed through the silicon membrane. The light is partially absorbed while transmitting the silicon wafer depending on the thickness of the membrane. Two photodiodes are used to detect the lights passing through the silicon membrane at different wavelengths. The difference of the readings is used to cancel out the common errors, hence leading to improved accuracy. The system is designed and simulated to verify its optical responses. The experimental setup of the system is implemented and the results are analyzed. The proposed Silicon membrane thickness monitoring system can be used to monitor and control the etching depth to achieve precise silicon membrane thickness as needed.

Electric circuit design

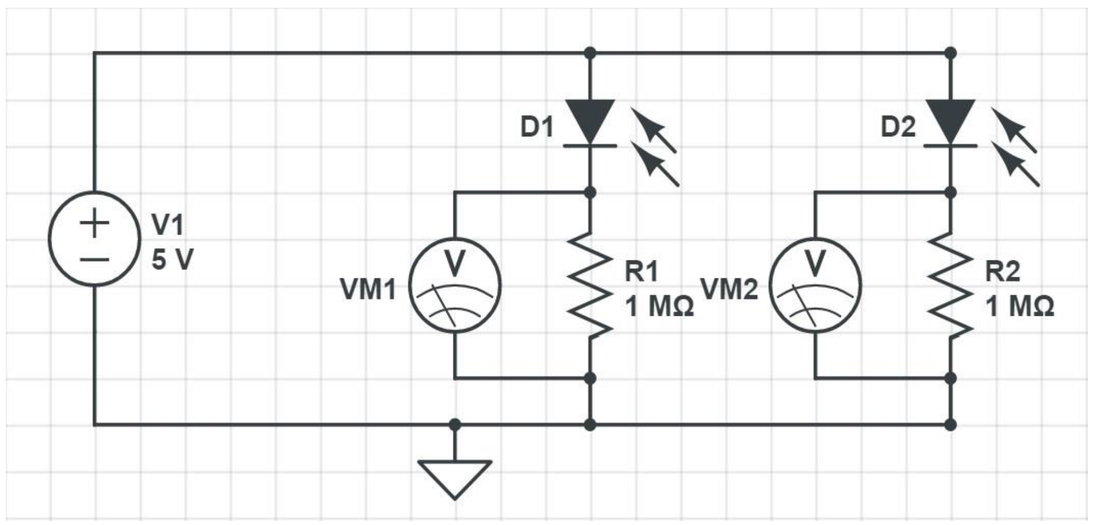


Figure 1. Electric Circuit for Signals Receive

Figure 1 shows the electric circuit design for light detector that is drawn by circuit ab website. In figure 2, the actual light detector has been build on a Arduino white board that can collect and record the real time data. There are tow photodiodes in circuit which are In GaAs photodiode and Si photodiode. They are using to receive different wavelength of light through wafer. Two resisters (1MΩ) using to detect the changing of voltage by the photodiode, and each one of resisters is in series with one photodiode.

It was using the 5V voltage by the USB charge of the laptop. At the same time, it is using the Multimeter to measure voltage of the resister.

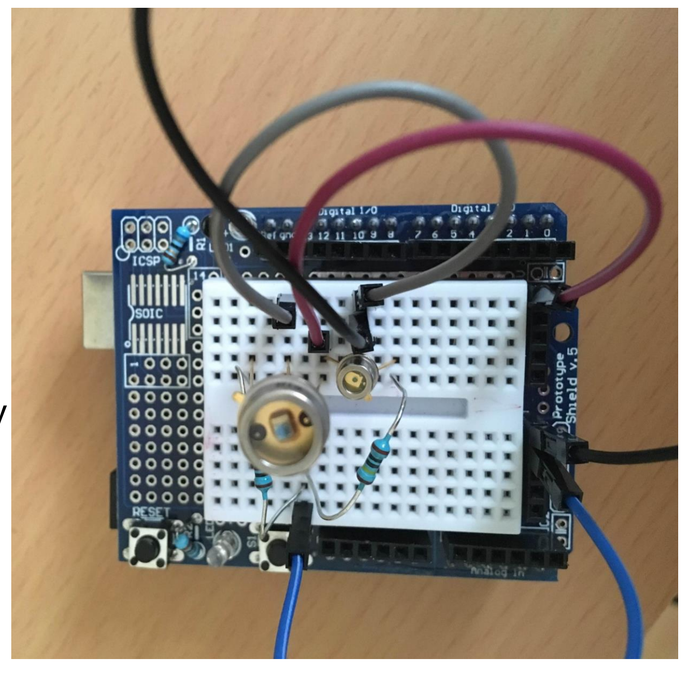


Figure 2. Circuit Connection

Wet etching setup

Material:

<100>silicon wafer(300-350um), self-designed etching chamber(PBA) by 3D printing, PMMA optical fiber, Potassium Hydroxide(Pellets), InGaAs and silicon Photodiode, Tungsten Halogen Lamp.

Wafer cleaning:

The <100> silicon wafer has been cleaned by the flowing steps:

1.Acetone ultrasonication for 90s

2.Isopropyl alcohol(90%) ultrasonication for 90s

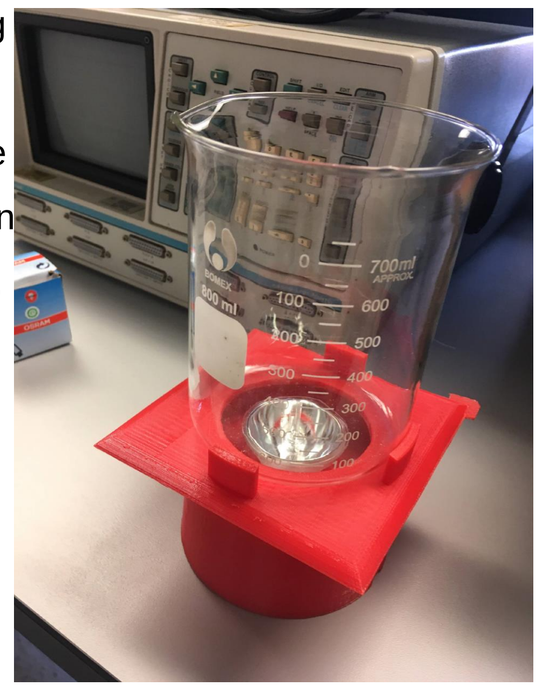
3.NH4OH ultrasonication for 90s

4.DI water ultrasonication for 90s

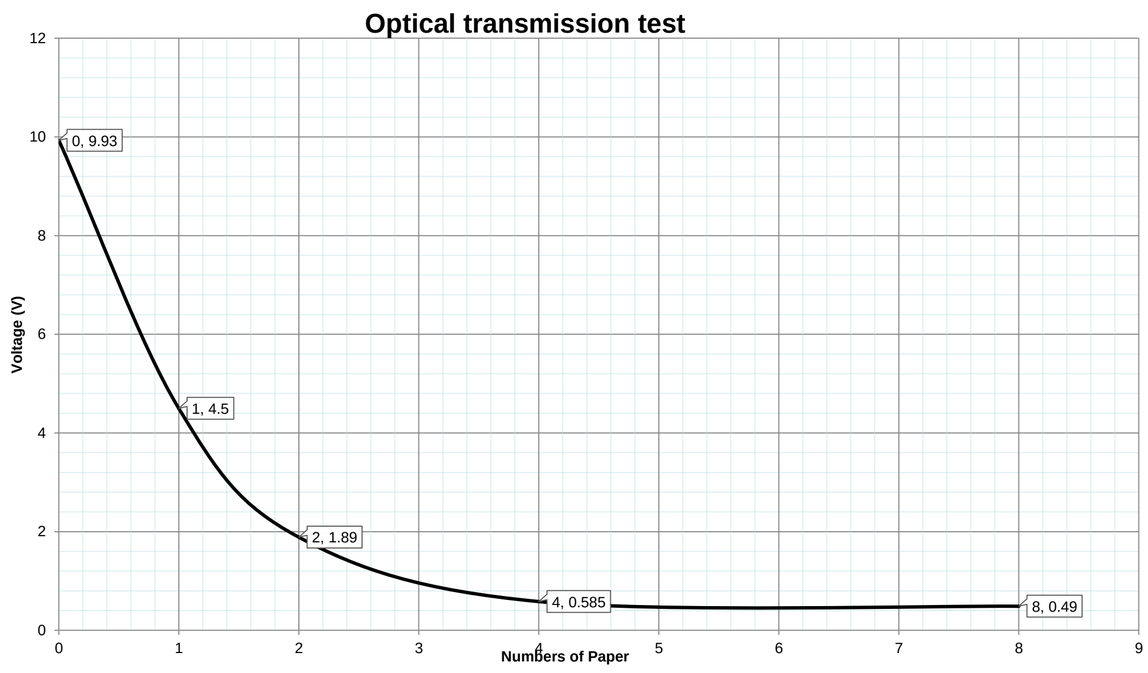
5.Room temperature for dry

Etching process:

In order to improve the accuracy of the result, the silicon wafer <100> with 300 um thickness is first immersed in boiling KOH solution(20% concentration) for 25 minutes. The etching rate for 20% concentration KOH at boiling temperature is 250um per hour. Then, the wafer has been transferred into self-design -ed etching chamber to continues etching, the thickness change during the wet etching process has been measured by illuminate light through the wafer and the light change has been detected by the photodetector.



Results



The figure below shows the result of the first stage of the experiment. The data measured is not actual during the etching process. The etching part going very well but still have several problem for signal collection. The signal received from photodetector is very weak and hard to capture the big difference between the thickness change. This can be improved either by enlarge the light intensity pass through the silicon wafer or increase the detect range of the detector. In the future, a dynamic real-time monitor system could be achieved.

Acknowledgments

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